2.1.3 Calmet Model Control Settings

Calmet was executed with surface data, upper-air data, precipitation data, and geophysical data as described previously, and with control file options/parameters generally established by published IWAQM guidance. As noted earlier, alternative settings were used in some cases where local testing of the model indicated an alternative setting is more appropriate. A listing of the most significant control file settings used by EPA are summarized in Table 2.1.3-1, and a listing of non-IWAQM settings used by EPA are shown in Table 2.1.3-2. The complete EPA Calmet input control file is available in electronic format from EPA Region 8.

Table 2-1
Calmet Control File

Parameter/Option	Value
No. surface stations	24
No. upper-air stations	6
No. precip stations	96
No. X grid cells	64
No. Y grid cells	46
No. vertical layers	8
Diagnostic wind module	Yes
Use O'Brien procedure	No
Extrapolate surface wind observations	-4
RMAX1	300 km
RMAX2	1200 km
TERRAD	100 km
R1	125 km
R2	100 km
No. barriers (NBAR)	0
MNMDAV	8
ILEVZI	4

Table 2-1
Calmet Control File

Minimum overland mixing height	50 m
Maximum overland mixing height	4000 m
TRADKM	500 km
SIGMAP	100 km

Table 2-2 Non-IWAQM Settings used by EPA in Calmet Control File

Parameter	IWAQM	Current EPA Study
IKINE	0	1
BIAS (Values for each vertical level)	0,0,0,0, 0,0,0,0	-1.0, -0.9, -0.7, 0.0 0.5, 1.0, 1.0, 1.0
LVARY	F	T
MNDAV	1	8
ILEVZI	1	4
ZIMAX & ZMAXW(over water)	3000 m	4000 m

The reason EPA selected each non-IWAQM setting in the current study is discussed below:

IKINE - The inclusion of kinematic effects reduced predicted concentrations by about 10 percent at the two monitoring sites providing somewhat better agreement between Calpuff results and monitored observations. There is a risk that use of this option will create unrealistic wind fields.

BIAS(NZ) - The IWAQM recommendation provides neutral bias (between surface and upper-air data) for all vertical layers. The meteorological data set used in the modeling

includes data from a large number of both surface and upper-air sites. Given the relatively rich set of measured data, both at the surface and aloft, it does not seem reasonable to assume equal weighting of upper-air wind data with surface data at the lowest level, and to assume equal weighting of surface data with upper-air data at top levels.

LVARY - This option was selected to ensure that at least one station would always be available for model input.

MNMDAV/ILEVZI - NDDH found that IWAQM default values for these parameters, relating to spatial averaging of mixing heights, produced unrealistic spatial variations in the mixing height field. Severe gradients (bull's eyes) in mixing height were observed in the immediate vicinity of meteorological stations, and the selected values in these input parameters smoothed the gradients. The overall area-wide average value of mixing height was not significantly affected by this change.

ZIMAX/ZIMAXW - In the western part of the upper Great Plains maximum summertime mixing heights frequently exceed the default value of 3000 m. A value of 4000 m was selected based on reported maximum mixing heights for this region (Holzworth, 1972)[4].

2.2 Calpuff Application and Postprocessing

EPA has generally used IWAQM default values in selecting Calpuff control file settings, unless local conditions indicate that alternative settings are more appropriate. In addition to selection of the most technically sound control settings, model execution time was a factor in selecting certain parameters. EPA reviewed the results of the NDDH testing discussed below and has initially selected Calpuff control file settings that are very similar to those used in the NDDH study.

2.2.1 Receptor Locations

A total of 49 receptor locations were selected for calculating concentrations in the 4 Class I areas in North Dakota and Montana. Maximum receptor spacing in the North Dakota Class I areas is about 5 kilometers. Receptor coverage for Medicine Lake and Fort Peck Class I areas was less dense because they are located further from the largest contributing sources, and local minor source emissions contributions could not be fully accounted for. Given the distances of the largest contributing sources from these Class I areas (150 - 300 km), concentration gradients would not be expected to be significant within individual areas, thus receptor coverage appears to be adequate. Additional receptors would also have the disadvantage of slowing Calpuff execution times. The receptor numbers correspond to receptor locations in the following Class I areas: Receptors 1 - 22, TRNP South Unit; Receptors 23 - 38 TRNP-North Unit; Receptor 39,

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[4] Holzworth, 1972, Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States, EPA, Office of Air Programs Publication AP-101

TRNP Elkhorn Unit; Receptors 40 - 44, Lostwood Wilderness Area; Receptor 45 Medicine Lake Wilderness; and Receptors 46 - 49 Fort Peck Reservation.

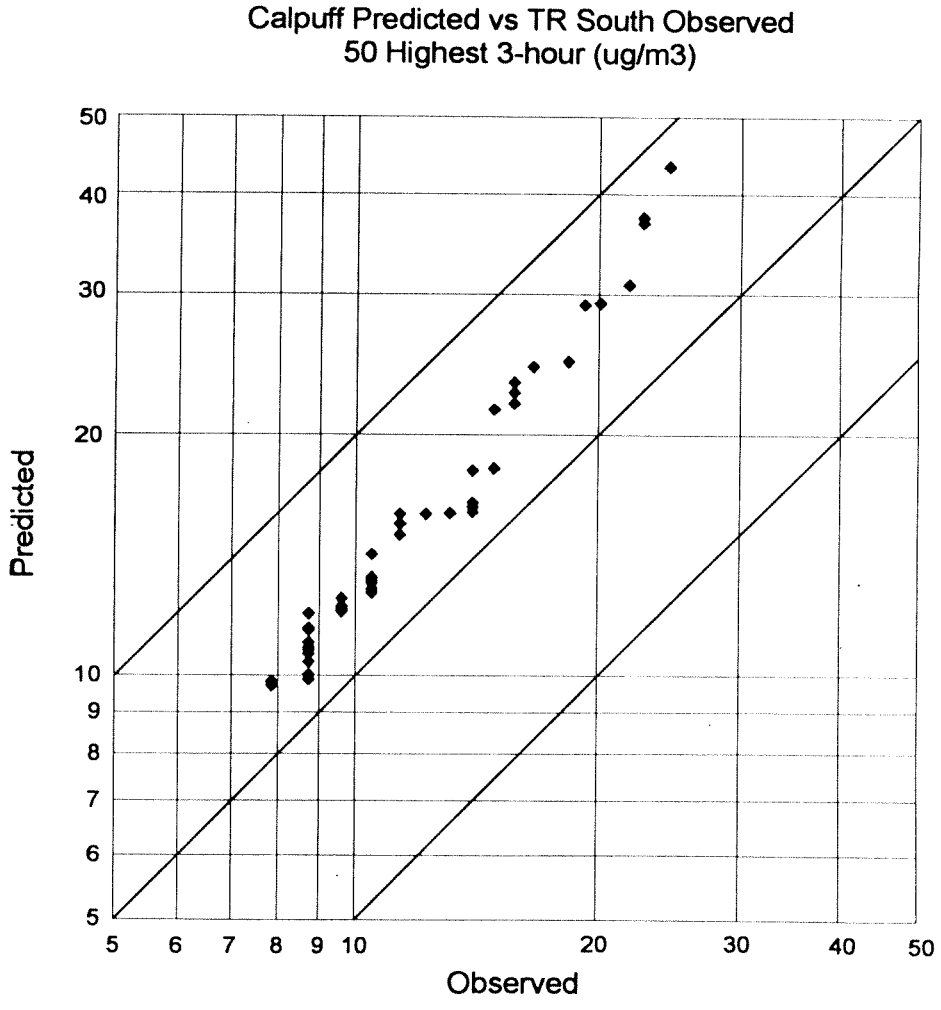
2.2.2 Calpuff Evaluation and Model Control Settings

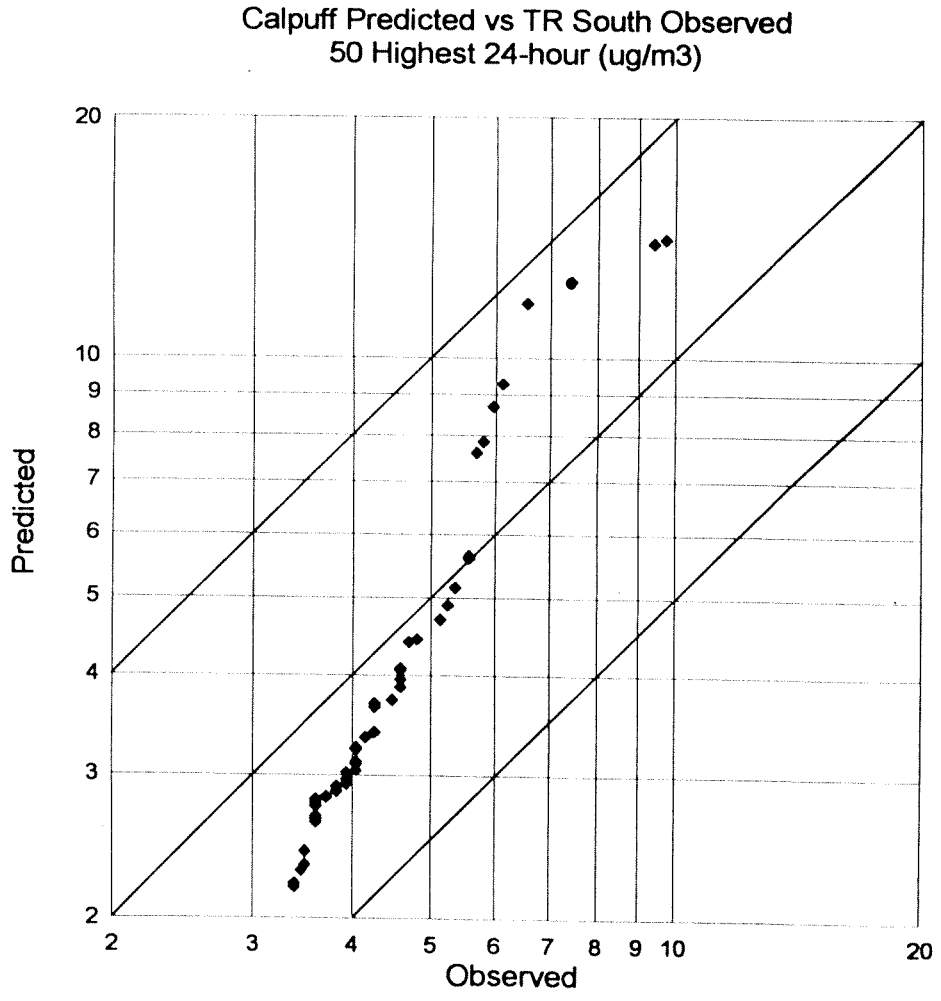
To determine the effectiveness of selected Calpuff control file settings, as well as the utility of the Calmet/Calpuff implementation in general, NDDH conducted a limited model performance evaluation, using data from two monitoring sites located in or near Theodore Roosevelt National Park. The NDDH Calpuff evaluation is described in the NDDH 1999 Calpuff Class I Modeling Study. Calpuff was tested in the NDDH study using Calmet meteorological data files prepared as described in Section 2. In general IWAQM default values were used in selecting Calpuff control file settings when other information was not available. Testing was conducted primarily to determine sensitivity of results and execution time associated with parameters/options for which default values were not provided. The goal was to achieve a technically competent implementation of the model while maintaining reasonable execution time. Calpost was applied to summarize Calpuff hourly output. Values for selected Calpuff control file parameters/options were individually and systematically varied to determine effect on results and execution time. NDDH conducted testing, for example, to determine sensitivity of results to deployment of puff splitting, terrain effects, PDF (Probability Distribution Function) for convective conditions, and partial plume penetration of elevated inversion. All seemed to have some effect on model results but, with the exception of puff splitting, none of these options caused a significant execution time penalty. Therefore, as in North Dakota's 1999 analysis, EPA has concluded it is appropriate to deploy all of these options for modeling major sources. Given the number of minor sources (principally oil and gas sources) along with execution time considerations, puff splitting will not be deployed for minor sources.

NDDH has continued to test Calpuff performance using year 2000 emissions and meteorology data.[5] The evaluation of Calpuff performance for Year 2000 data at Dunn Center and TRNP South Unit monitoring sites still indicates the modeling system performs relatively well, when implemented using IWAQM control file settings as modified by NDDH. In these latest results, shown in Figure 2-2, predicted-to-observed ratios (unpaired in time) for the fifty highest predicted/observed concentrations fell within the factor-of-two criteria suggested by EPA guidance, and did not exhibit a strong systematic bias toward underprediction or overprediction. EPA has some concern, however, that the 24-hour averages at TRNP South Unit are underpredicting concentrations, particularly for rankings lower than the top ten values. For increment consumption modeling, the limiting concentrations (i.e. the highest second-high predicted concentration for each year modeled) would not necessarily occur under conditions that

[5] NDDH Draft Report, Evaluation of Calpuff Model Performance Using Year 2000 Data, November 2001

Figure 2-2





Source: NDDH Draft Report, Evaluation of Calpuff Model Performance using Year 2000 Data, November 2001

lead to the top 10 ranked values shown in the figure. This is due to the fact that increment analysis involves modeling a limited number of emitting sources in the region, while NDDH's performance testing of the model necessarily involved modeling all major sources in the region.

EPA has reviewed the NDDH testing and evaluation results along with the latest IWAQM guidance and selected the Calpuff control file settings summarized in Table 2-3. Non-IWAQM settings are shown in Table 2-4 and the reasons for their selection are discussed below. In the current draft analysis EPA has generally used the same NDDH model settings as were used in the Draft 2000 model evaluation study discussed above, despite some concerns about possible model underpredictions. A test run using regulatory default model settings has also been done and these results are discussed in Section 4.1.

Table 2-3 Calpuff Control File

Parameter/Option	Value
No. chemical species	5
Vertical distribution near field	1
Terrain adjustment method	3
Subgrid-scale complex terrain	0
Slug model	No
Transitional plume rise	Yes
Stack tip downwash	Yes
Vertical wind shear	No
Puff splitting	Yes
Chemical mechanism	1
Wet removal	Yes
Dry deposition	Yes
Dispersion coefficient method	2
Partial plume penetration - elev. inversion	Yes
PDF used under convective conditions	Yes
CSPEC	SO_2, SO_4, NO_x, HNO_3, NO_3
Chemical parameters - dry gas deposition	Default

Table 2-3 Calpuff Control File

Parameter/Option	Value
Size parameters - dry particle deposition	Default
RCUTR	30.
RGR	10.
REACTR	8.
NINT	9
IVEG	2
Wet deposition parameters	Default
Ozone data input option	1
Background ammonia conc. (ppb)	2.
SYTDEP	550.
MHFTSZ	0
JSUP	5
XSAMLEN	0.5
MXNEW	99
MXSAM	99
Maximum mixing height (m)	4000.
Minimum mixing height (m)	50.
NSPLIT	3
IRESPLIT	Hour 17-22 = 1
ZISPLIT (m)	100.
ROLOMAX	0.25

Table 2-4 Non-IWAQM Settings Used by EPA in Calpuff Control File

Parameter	IWAQM	EPA
MSPLIT	0	1
MDISP	3	2
BCKO3	80 ppb	30 ppb
BCKNH3	10 ppb	2 ppb
XSAMLEN	1.0	0.5
XMAXZI	3000 m	4000 m
MPDF	0	1

MSPLIT - The option for puff splitting is employed when modeling source-receptor distances of 200 km or more, because of the tendency for Calpuff to otherwise overpredict at these distances. Deployment of this option also provided better agreement with observations.

MDISP - Use of dispersion coefficient option 2 provided better agreement with observations. Selection of this option reduced predicted concentrations by 25 percent or more at some receptors.

BCKO3 -EPA used files of measured hourly ozone concentrations to establish background values, however, the BCKO3 value is substituted by Calpuff when hourly data are missing. Based on local monitoring data the IWAQM value of 80 ppb appears to be too high for North Dakota conditions, and therefore was reset to 30 ppb.

BCKNH3 - The value of 2 ppb reflects the annual average of local, unbiased monitoring data.

XSAMLEN - This value was set lower than the IWAQM recommendations to improve model resolution by increasing the number of puffs and decreasing mass per puff. The

only negative consequence for revising this option would be extra computer processing time due to more puffs on the grid.

XMAXZI - Value was increased to 4000 m for consistency with ZIMAX/ZIMAXW setting in Calmet.

MPDF- This option should be deployed when dispersion option 2 is selected.

3. Emission Inventory for Class I Increment Analysis

In general, the source emission inventory for any increment analysis consists of all increment-affecting sources[6]. Specifically, this would include actual emissions from:

(1) any major stationary sources for which construction began after the major source baseline date (which, for SO_2 is January 6, 1975);

(2) any existing major stationary sources having undergone construction (*i.e.*, a physical change or change in the method of operation) after the major source baseline date;

(3) any existing stationary sources having undergone a physical change or change in the method of operation, or having increased hours of operation or capacity utilization, after the minor source baseline date;

(4) any new stationary sources which were constructed after the minor source baseline date; and

(5) any changes in emissions from area and mobile sources since the minor source baseline date.

The "minor source baseline date" is defined as the earliest date after the "trigger date" (which for SO_2 is August 7, 1977) that a major stationary source or major modification submits a complete PSD permit application. The minor source baseline date is set for the baseline area for the increment pollutant which the source would emit in significant amounts. (See 40 CFR 51.166(b)(14)(ii) and (iii), 40 CFR 52.21(b)(14)(ii) and (iii)). The applicable minor source baseline date in any increment analysis is the minor source baseline date *for the area that is being modeled for impacts*. The SO_2 minor source baseline date was triggered for the North Dakota "Rest of State" (Air Quality Control Region 172) SO_2 attainment area on December 17, 1977. So, for assessing the impacts in Theodore Roosevelt National Park and Lostwood

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[6] New Source Review Workshop Manual, Part I, Chapter C, Section IV.C.2, p. C.35, Draft October 1990, EPA, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, http://www.epa.gov/ttnnsr01/gen/wkshpman.pdf.

Wilderness Area (both included in Air Quality Control Region 172), the applicable minor source baseline date is December 17, 1977. The SO_2 minor source baseline date for the Medicine Lakes Wilderness Area and the Fort Peck Indian Reservation in Montana was triggered on March 26, 1979, over a year later. Therefore, two emission inventories were compiled for this analysis: the inventory for the North Dakota Class I areas includes all increment affecting sources based on a minor source baseline date of December 17, 1977 and the inventory for the Montana Class I areas includes all increment affecting sources based on a minor source baseline date of March 26, 1979. Note that, the NDDH did not develop a separate inventory for the Montana Class I areas in their 1999 draft modeling analysis. Their results are based only on North Dakota's December 17, 1977 minor source baseline date.

The two inventories include increment consuming, as well as increment expanding sources and consist of all major PSD sources located within 250 km of each Class I area as well as minor sources located within 50 km of each North Dakota Class I area[7]. The major source inventory includes increment consuming emissions from eight coal-burning power plants (one of which is located in Montana), two gas processing plants and a coal gasification plant (see Figure 2-1) as well as increment expanding emissions from five major sources that all shut down after the applicable minor source baseline dates.

Modeled emissions (*i.e.*, increment consuming/expanding emissions) are determined by subtracting base year emissions from current year emissions, for each existing source. For sources constructed after the applicable baseline date, modeled emissions are the source's current year emissions minus zero emissions in the base year (*i.e.*, all emissions are modeled as increment consuming). For sources shut down after the applicable baseline date, modeled emissions are zero emissions in the current year minus the source's base year emissions (*i.e.*, all emissions are modeled as increment expanding).

3.1 Current Year Inventory

In general, emissions for the current year inventory are based on actual emissions reflected by normal source operation for a period of two years. The two-year study period should generally be the most recent two years, provided that the two-year period is representative of normal source operation. Another two-year period may be used, only if that other period of time is more typical of normal source operation than the two years immediately preceding the date of

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[7] The minor source inventory consists primarily of emissions from oil and gas facilities located in North Dakota. At the time of this report, emission and stack data were not available for the oil and gas production facilities found in the vicinity of Medicine Lakes Wilderness Area and Fort Peck Indian Reservation in Montana. Therefore, these minor source contributions were not accounted for in modeling PSD increment consumption in Montana Class I areas. Also, NDDH is updating the base year and current year oil and gas emission inventory for North Dakota. The current EPA modeling does not include emissions, either increment expanding or increment consuming, from these sources. EPA intends to incorporate NDDH's revised oil and gas emissions inventory, if available, into the final modeling analysis. We note, however, that given the relatively small magnitude of SO_2 emissions from oil and gas sources, the effect of including these sources in the final modeling analysis is likely to be small.

concern. (See 45 FR 52718, August 7, 1980). For the most part, the current year inventory for this analysis is based on continuous emission monitor system (CEMS) data from 1999 and 2000 as reported to the EPA Acid Rain Database.

Following is a brief description of each major source that was constructed after the major source baseline date for SO_2 (see Section 3.2 for similar descriptions on the baseline sources, all constructed before the major source baseline date). Information is based on data from EPA's Acid Rain Database (see http://www.epa.gov/airmarkets/picturethis/index.htm):

Basin Electric Power Cooperative - Antelope Valley Station
Unit 1 - 435 MW, tangentially-fired lignite boiler, SO_2 control - (dry lime) flue gas desulfurization (FGD)
Unit 2 - 435 MW, tangentially-fired lignite boiler, SO_2 control - (dry lime) FGD

Otter Tail - Coyote Station
Unit 1 - 450 MW, cyclone-fired lignite boiler, SO_2 control - (dry lime) FGD

Great River Energy - Coal Creek Station
Unit 1 - 506 MW, tangentially-fired lignite boiler, SO_2 control - (dry lime) FGD
Unit 2 - 506 MW, tangentially-fired lignite boiler, SO_2 control - (dry lime) FGD

PPL Corp. - Colstrip (Montana)
Unit 3 - 778 MW, tangentially-fired boiler, SO_2 control - (wet lime) FGD
Unit 4 - 778 MW, tangentially-fired boiler, SO_2 control - (wet lime) FGD

Great River Energy - Stanton Station
Unit 10 - 60 MW, tangentially-fired boiler, SO_2 control - (dry lime) FGD

Hourly CEMS data for 1999 and 2000 for each of the eight power plants in the major source inventory (including 4 baseline sources) were obtained from EPA's Acid Rain Program. For each source, daily average emissions (24 hour averages) were calculated. Since it is highly unlikely that, simultaneously, all sources would operate at their peak actual emissions during the same 24-hour averaging time, we chose to model the 90th percentile actual emissions for each unit. In reviewing the 1999 and 2000 CEMS data, EPA found that the 90th percentile cumulative emission rate (*i.e.*, the sum of all of the 90th percentile emission rates at each facility) did actually occur several times. Therefore, given that, and the fact that these power plants are primarily used as base-load facilities, this seems like the most representative method for determining current year emissions, and provides a reasonable estimate of worst case conditions that may recur in the future.

The 90th percentile emission rate for each source was determined by ranking (from highest to lowest) the source's 24-hour average emission rates over 2 years - for a total of 730 emission rates (where the data record is 100% complete) - and selecting the 73rd highest 24-hour

average emission rate from the list. This single emission rate was then modeled for every 24-hour period over the 5 years of meteorology data used in the model.

There are a couple exceptions to the above method for determining current year emissions. Current year emissions for Great River Energy's Coal Creek Station are based on year 2000 CEMS data only. Both units at the Coal Creek Station reduced their SO_2 emissions by approximately 20,000 tons (combined) in 2000. Prior to 2000, roughly 40% of the units' emissions were bypassing the wet lime scrubbers used to control SO_2 emission from the stacks. In 2000, the facility greatly reduced this bypass, resulting in approximately 20,000 tons of SO_2 emissions reduction over the year. Both units at Coal Creek Station are subject to the Acid Rain Program's Phase II requirements (which applied, starting in 2000, to all existing utility units serving generators with an output capacity of greater than 25 megawatts). Therefore, the source was able to sell surplus SO_2 emission allowances that resulted from this reduction. While the reduction at Coal Creek is not necessarily permanent or enforceable, the facility has indicated that it intends to continue to operate at year 2000 emission levels. EPA agreed to model the source's current year emissions using only 2000 data with the understanding that the source would need to make those reductions permanent and enforceable if, in fact, they are needed to show compliance with the SO_2 Class I increments.

Montana-Dakota Utilities Co.'s Heskett Station (Unit 1) emissions are also only based on year 2000 CEMS data. Unit 1, at 25 MW, is not required to report to the EPA Acid Rain Database. Since hourly CEMS data were only available for the year 2000 from the State we did not include 1999 emissions in our calculations. Unit 1 is a relatively small part of the inventory so we did not pursue obtaining 1999 CEMS data for the Unit.

PPL Corporation's Colstrip power plant in Montana has 4 units. Units 1 and 2 were both constructed before the major source baseline date for SO_2 (January 6, 1975). We did not obtain baseline emission information for these units but know, from reviewing the available data in the EPA Acid Rain Database, that emission trends from 1980 to today are relatively flat or even slightly down. This suggests that increment consuming emissions would be low and so we did not include these units in the inventories. Units 3 and 4 were both constructed after the major source baseline date for SO_2; emissions for both units were obtained from the EPA Acid Rain Database and are based on 1999 and 2000 CEMS data divided by 365 days to estimate 24 hour emissions. A more refined analysis could be made of Units' 3 and 4 increment consuming emissions, to be consistent with the methodology used for major North Dakota sources, however such an analysis did not seem warranted given the units' geographic location and, consequently, their negligible contribution to increment concentrations in any of the Class I areas modeled.

Current year emissions for the power plants are summarized in Table 3-1.